

THE DEVELOPMENT OF TWO AUSTRALIAN SPONGE-CRABS.

By HERBERT M. HALE, Zoologist (Crustacea), South Australian Museum.
(Contribution from the South Australian Museum.)

(Plates xxxix-xl, and five Text-figures.)

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It has been often stated that all marine Brachyura hatch as Zoeae, and pass through two or more pelagic larval stages before reaching the adult form. In 1914, however, Miss Rathbun recorded a female of *Paranaxia serpulifera* from the Monte Bello Islands, Western Australia, with "young crabs in the adult state" beneath the pleon; she remarks that juveniles in two stages thus accompany the mother "but whether the first is hatched directly from the egg or not, it is impossible to tell"; both young stages are figured by Rathbun. The complete life-history of the majority of marine crabs is unknown, and Rathbun (1918), bearing in mind the case of the Spider-crab from Australia, later pertinently remarks, "It is unwise to draw sweeping conclusions from a few cases".

In 1922, Montgomery described some well developed young taken from beneath the pleon of an Australian Dromiid crab (*Paradromia lateralis*), and states that, apart from Rathbun's Oxyrhynch, "this is the only other available record of such a case among marine Brachyura". Indication that some Australian Sponge-crabs do not have pelagic larval stages is to be found, however, in a paper by Haacke (1885), who suggested that the free-swimming larvae of sponges and Tunicates lodge on the carapaces of the young crabs sheltering under the abdomen of their parents, and that each member of a brood thus acquires its cloak from the mantle of its mother. The title of Haacke's paper does not indicate that these juvenile crabs are mentioned by him, and he does not remark upon their presence beneath the pleon as unusual; further, the names of the Dromiids concerned are not given.

Haacke states that he examined pea-sized Dromiids which had the sponge-cloak firmly fastened to the carapace (and not merely held in position with the posterior chelipeds) so that the crabs could not be robbed of their covering without injury. He then concludes that, as stated above, the cloak is possibly acquired very early in life, and that as a result of this probable "erblicher Symbioses", there is a tendency for different Dromiid species to have special species of sponges and Ascidians.

There are before me an adult female of *Cryptodromia octodentata* with young beneath the abdomen, and several specimens of *Paradromia lateralis* likewise burdened. The ova of these two species, as is usual with crustaceans which have a "direct" development, are relatively large; this is also the case with a third Australian Sponge-crab—*Platydromia thomsoni*—and leads one to suspect that this species likewise hatches at an advanced stage. The metamorphosis is apparently almost completely suppressed in *Paradromia lateralis* and *Cryptodromia*

octodentata, and possibly in *Paranaxia serpulifer* also; it must be remarked, however, that the pleopods of the juveniles of the two Sponge-crabs are very similar to the natatory abdominal appendages of the Megalopas of some other crabs.

CRYPTODROMIA OCTODENTATA Haswell.

Cryptodromia octodentata is one of the largest of the Australian Sponge-crabs, the carapace of some specimens attaining a width of 85 mm. The cloak is usually a sponge or, more rarely, a mass of Ascidians, but sometimes other objects are held over the carapace. A specimen recently observed was using a piece of kelp weed as a shield and the ovigerous female illustrated on Plate xl is sheltered by the valve of a Fan-shell (*Pecten medius*); this shell admirably fits the back of the crab, and portion of it is so conveniently broken as to enable the crustacean to grip the inner edges of the chipped part with the hind chelae and so hold the mask firmly in position. An old example, 74 mm. in width, holds no shield on the back, but the carapace is considerably eroded and attached to it is an assortment of marine growths, including two species of plants.

The pleon of the adult female, with the aid of the exopods of the pleopods, forms a veritable pouch for the retention of the ova and later, as it proves, for the little crabs. In large examples the abdomen is half as wide as the carapace and, if it be closely adpressed, its tip overlaps the basal fourth of the outer maxillipeds; thus, when the tip is placed in its normal position between the anterior edges of the coxae of the large chelipeds, the greater part of the pleon stands away 10 mm. or so from the body. In specimens which bear a large mass of eggs, the abdomen is naturally forced far out of its usual position, but the contents of the apron are prevented from falling out by the large, flattened exopods of the second to fifth pleopods (Text-fig. 5*b*); the outer rami of these appendages are densely fringed with outstanding hairs, and are so shaped that, when pushed outwards by the eggs or young, they overlap and form perfect side walls to the brood pouch. The ova of some dried examples are more than 1 mm. in diameter but were probably larger in life, for Rathbun (1923) states that "The eggs are very large and numerous, being 2 mm. in breadth"; the ova are attached to the long hairs of the slender, two-jointed endopods of the pleopods.

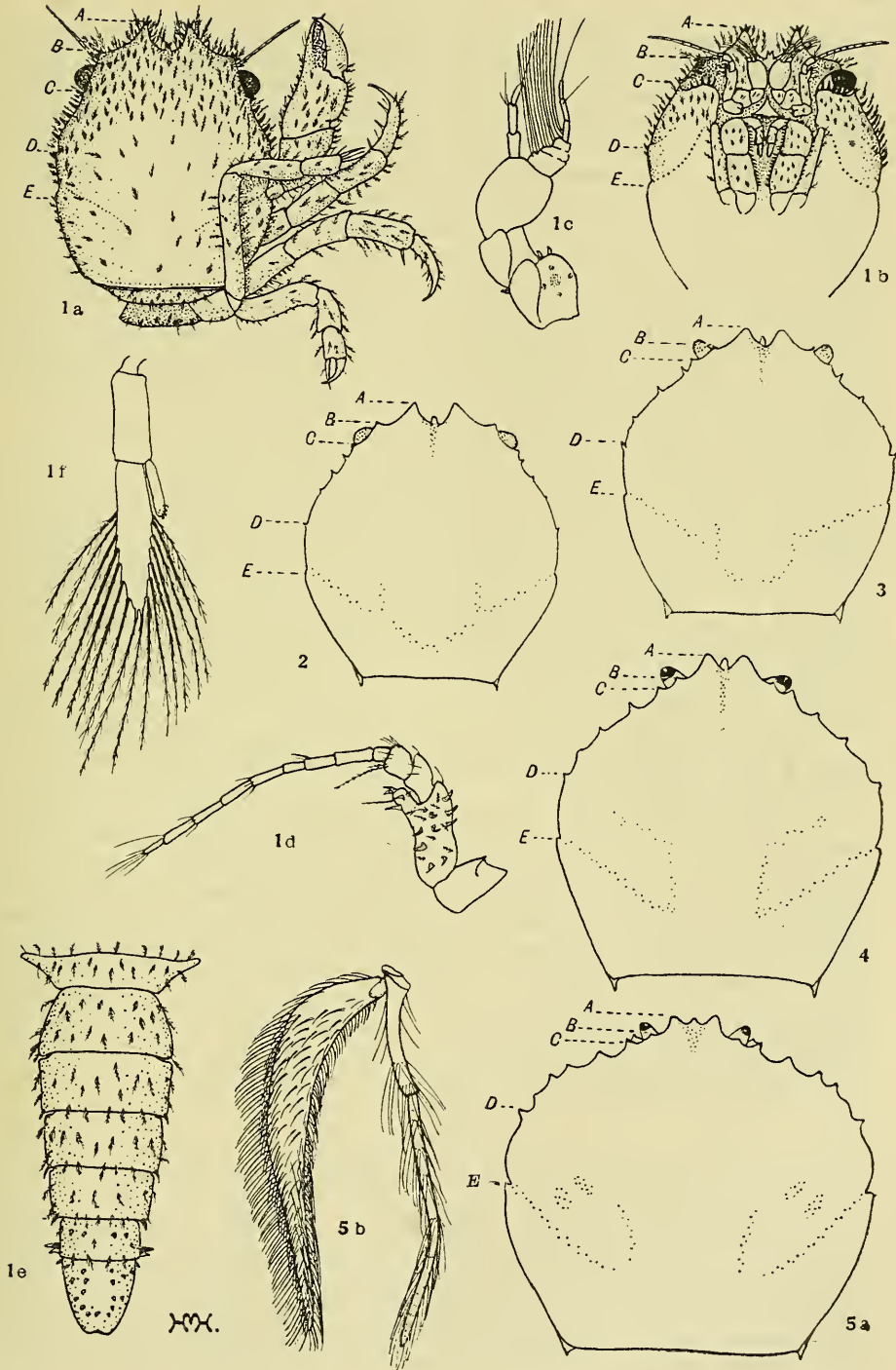
As previously mentioned, one female (preserved in alcohol) has a number of juveniles under the pleon; in this case the capacity of the brood pouch is strained to the utmost, for the well developed family consists of five hundred and thirty individuals (Pl. xxxix). The pleon and the exopods of the pleopods are forced far out from the body to accommodate the young crabs, some of which have the legs clasped around the hairs of the endopods of the pleopods. A description of these juveniles, and notes concerning a few of the succeeding stages, are given below.

Brood Young. Text-figs. 1*a* to 1*f*.

Colour completely bleached. Exoskeleton thin. Carapace very convex, about one-fourth longer than greatest width, the surface smooth and clothed with

Text-figs. 1-5.—*Cryptodromia octodentata* Haswell.

1. Brood young; 1*a* and 1*b*, dorsal and ventral views ($\times 12$ diams.); 1*c* and 1*d*, first and second antennae ($\times 33$ diams.); 1*e*, pleon ($\times 21\frac{1}{2}$ diams.); 1*f*, pleopod of fifth segment ($\times 53$ diams.).
2. Carapace of young example 6.9 mm. in width ($\times 5$ diams.).
3. Carapace of young example 15 mm. in width ($\times 2\frac{1}{2}$ diams.).
4. Carapace of half-grown example 29 mm. in width ($\times 1.4$ diams.).
5. Adult female; 5*a*, carapace ($\times 0.9$); 5*b*, pleopod of fifth segment ($\times 1.9$ diams.).



moderately long hairs, which are plumose for their whole length; the hairs are sparse on the posterior two-thirds of the dorsum. Branchial (or cervical) groove not very distinct. Front cut into three teeth, the median projection small, down-bent and apically bifid; each of the outer teeth (Text-figs. 1a and 1b, A) is capped with three or four short, stout spines and has plumose hairs and a few spines on the margins. A strongly marked angle (the supraorbital tooth) at about the middle of the orbit bears three spines (Text-figs. 1a and 1b, B). The outer, or posterior, angle of the orbit is slightly prominent and bears two or three spines (Text-figs. 1a and 1b, C). The anterolateral borders are provided with five to seven spines and with plumose hairs, and are a little incised at about two-thirds of their length (Text-figs. 1a and 1b, D), the incision followed by a slight protuberance which bears the last spine or two of the anterolateral series. The posterolateral margins are slightly convex and convergent, furnished anteriorly with a few spines and plumose hairs; there is a projection of the margin immediately behind the branchial groove (Text-figs. 1a and 1b, E).

Suborbital lobe armed with five or six spines; no notch in the orbital margin below the outer angle. Subhepatic region very slightly swollen.

First antennae (Text-fig. 1c) with peduncle stout, three-jointed; with two flagella, the inner of which is short, slender and composed of three articles, while the outer lash consists of six articles (the basal three stout) and is furnished with a dense brush of long hairs. Peduncle of second antennae four-jointed (Text-fig. 1d); second article furnished with spines and a few plumose setae; with inner angle slightly produced and with outer apical part strongly forwardly produced and lobular; flagellum rather long, composed of nine articles.

Eyes large. Margins of ischium and merus of third maxillipeds furnished with short, stout spines.

Chelipeds and legs much as in adult, armed with some marginal spines, with slender, plumose setae and (near apices) with a few simple setae; serrations of fingers of large chelae coarse.

Pleon bent under body, narrow, seven-segmentate, furnished with plumose hairs and a few short spines; apex of telson slightly incised; third to fifth segments with one spine, and sixth with two spines, at each posterolateral angle (Text-fig. 1e). Pleopods of second to fifth segments stout, long, each with protopod large and more than half as long as exopod, which is flattened and provided with sixteen long, plumose hairs on the margins; endopod rudimentary, unjointed, not much more than one-third as long as exopod and with apex furnished with four minute hooks (Text-fig. 1f); the apex of the exopod of the last pair of pleopods reaches to level of three-fourths of length of telson, and the fringing hairs extend well beyond apex of pleon.

Length of carapace, 2.8 mm.; width of carapace, 2.2 mm.

Growth Changes. Text-figs. 2-5.

There is also before me a series of examples of various sizes, most of the small specimens being preserved in a dry state.

The smallest member of this series is 4.8 mm. in length and 4.1 mm. in width, and differs from the brood young in the following particulars: The carapace is relatively slightly wider at about the middle of its length and the front is relatively a little narrower. The median tooth is very obscurely subbifid, is bent downwards and slightly forwards, and bears a few small lateral spines. Many of the marginal spines persist, but are very tiny. The posterior (outer) angle of

the orbit is more prominent, and below it is a small V-shaped notch. The supra-orbital tooth is more acute. The suborbital lobe bears tiny spines and the inner angle is acute. The anteroexternal angle of the buccal cavern is somewhat acute and behind it is a slight projection. Four tiny spiniform projections have developed on the anterolateral margins; the first has two spines on its anterior slope, the third is minute, and the fourth is just behind the incision (*D* in the figures) which is very much less distinct than in the brood young. The clothing (which is mostly denuded) is of the same character, but the hairs are relatively smaller. The apex of the pleon is narrowly rounded.

It has been determined that in some other Decapods the general increase in size after a moult amounts to roughly one-sixth, so that if we venture here to apply an approximate rate of growth, this specimen, since attaining the size of the brood young, has passed four, or at most five, ecdyses.

The next example is 7.8 mm. in length and 6.9 mm. in width (Text-fig. 2); thus, in proportion, the carapace is again wider and the front narrower. The median projection is simple and is still more forwardly directed. The suborbital lobe bears a few tiny spines and the inner angle is dentiform. The first of the small anterolateral teeth has three minute spines on its anterior slope. The clothing of the dorsum is denuded, but that of the subbranchial regions consists of slender hairs, sparsely plumose for their whole length, and that of the anterior parts of the under surface of short and densely plumose hairs.

A specimen 15.5 mm. in length is 15 mm. in width. The median frontal projection is nearly horizontal. The suborbital lobe bears no tiny marginal spines. The anteroexternal angle of the buccal cavern is spiniform and the projection near it is conical. The first of the four teeth of the anterolateral margins is larger than the others, and immediately in advance of the fourth is a very slight protuberance. The dorsum is densely clothed with erect setae, each of which is provided with tiny lateral spikelets, the lastnamed being largest on the apical half. The subbranchial regions bear thin and very sparsely plumose hairs.

The carapace of individuals 29-30 mm. in length (Text-fig. 4) is as wide as long. The projection or tubercle just in advance of the last tooth of the anterolateral series is usually moderately prominent, and near it there is sometimes an additional low tumidity on the dorsum of the carapace. The clothing consists of setae which have a brush of lateral setae on their distal half and others (more particularly on the legs) which have lateral spikelets for almost their whole length.

The female with brood is 50 mm. in length and 53 mm. in width (Text-fig. 5a); comparing this individual with the juveniles it is now evident that the following changes occur during growth. At each moult the carapace grows relatively wider behind the level of the orbits and relatively smaller in front of this level, so that, while the distance between the hinder angles of the orbits is more than three-fourths of the width of the carapace in the young, it is not much more than one-third of the width in the mature female. Thus that part of the anterolateral margins in front of the incision (*D*) gradually becomes more oblique and the portions posterior to the notch (which at first slope outwards) eventually converge. At an early period the tiny marginal spines disappear and four dentiform projections appear on the anterolateral margins while, later, a fifth tubercle (more or less distinct) is developed, very close to the incision (*D*) which then resembles the interspaces between the other teeth. The projection of the margin below the branchial groove assumes a more or less dentiform or lobular character. The

supraorbital tooth gradually becomes relatively smaller and the outer angle of the orbit more prominent, while a notch appears in the orbit below this angle; the inner angle of the orbit becomes spiniform. A conical tooth develops below the anteroexternal angle of the buccal cavern, which also becomes spiniform. The tumidity on the subhepatic region is accentuated. The clothing changes in character and is finally very dense. The serrations of the fingers of the large chelipeds increase in number, and small tubercles take the place of tiny marginal spines. Additional articles are gradually developed in the flagella of the antennae. The basal article of the peduncle of the first pair is now relatively stouter and the third thinner than in the young; the slender inner lash consists of fourteen articles and the tapering outer flagellum of thirty-two articles, with a dense brush of hairs. Both inner and outer distal angles of the second article of the second antennae are produced and the flagellum contains forty-two articles. In the female the abdomen increases in width. The pleopods change entirely; it is probable that the four pairs of immature abdominal appendages atrophy at an early stage, and that the permanent pleopods of both sexes then develop. Hyman (1920) shows that this happens in *Uca pugilator*.

It has been noted above that the species attains a width of 85 mm. It is evident that the relative widening of the carapace at each moult obtains throughout the life of the animal, for in very large examples the carapace is approximately one-sixth wider than long. In aged specimens the chelipeds, particularly in the males, are very strong, with the serrations of the fingers blunt, and the marginal tubercles are often spiniform. The fourth projection of the anterolateral margins of the carapace may be acutely spiniform, as are the others. The projection behind the branchial groove is prominent, and a row of more or less conical teeth may develop on the posterolateral margin; traces of these posterolateral teeth are sometimes found in small examples. The branchial groove is usually deep and in two examples the cardiac region is well delineated.

All the specimens dealt with above were taken in St. Vincent Gulf, South Australia.

PARADROMIA LATERALIS Gray. Plate xl, B.

The brood pouch of this species is much as in *Cryptodromia octodentata*; the pleon of an adult female, when closely folded against the sternum, reaches to the middle of the length of the outer maxillipeds. The ova are large, an advanced egg taken from a female 17 mm. in width being 1.14 mm. in length and 1 mm. in width; Henderson (1888) records an ovigerous female from Bass Strait.

I am much indebted to Mr. Melbourne Ward for a female of *Paradromia lateralis*, 14 mm. in width, with young in the apron; this specimen was recently secured "On reef at Shelly Beach, Manly, New South Wales; on sand under stones below low tide." Several dried examples from St. Vincent Gulf also have young in the brood pouch and in one case juveniles in two stages are present.

Brood Young, 1.

The little crabs in the earlier stage are very soft, and when relaxed have the appearance of being ready to moult. They are only one-third larger than the ripe ova, being approximately 1.5 mm. to 1.6 mm. in length and 1.15 mm. to 1.25 mm. in width. The pleon is somewhat loosely flexed; the pleopods of the second to fifth segments are much as in the next stage, each having a long protopod, a long flattened and hair-fringed exopod and a short endopod with minute apical hooks.

These examples, judging from their dimensions, are representatives of the stage described by Montgomery (1922), but their condition is too poor to warrant further description here. The peraeopods are moderately stout and the lastnamed author treats this stage as "definitely post-larval", although the pleopods are certainly not "similar to those of the adult" as he states. It is strange that the sedentary young of this species and of *Cryptodromia octodentata* should retain pleopods well developed for swimming.

Brood Young, 2. Plate xl, B, figs. 1a to 1f.

The young of the next stage are about one-fourth larger than those of the preceding (the proportionate increase is greater in Rathbun's *Oxyrhynch*, namely, "more than one-half"). About twenty examples of this instar are contained in the pleon of the female collected by Mr. Ward, and the following description is based upon these fresh specimens:—

Colour olivaceous-brown. Exoskeleton thin. Carapace very convex, not much longer than greatest width; dorsum furnished with short spines intermixed with setae which are shortly and sparsely plumose; regions moderately well defined and branchial groove distinct. Front a little downbent, with three teeth, the median of which is armed with three spines on each lateral margin; lateral margins of outer teeth with stout spines and setae similar to those of dorsum, and apices capped with three to four spines (Pl. xl, fig. 1a, A). A large supra-orbital tooth (Pl. xl, fig. 1a, B) at the middle of the length of the orbit bears three apical spines, and between it and the posterior angle of the orbit is an inconspicuous projection armed with two spines. Posterior margin of orbit bent abruptly outwards and furnished with a spine; hindermost point of orbit (Pl. xl, fig. 1a, C) not prominent, but margin of carapace immediately beyond this point curved backwards, thus forming a somewhat rounded projection (Pl. xl, fig. 1a, D) which is furnished with about five spines. Behind this is another prominent protuberance of the lateral margins (Pl. xl, fig. 1a, E). Posterolateral margins a little sinuate and slightly convergent, provided with a few spines and setae; there is a projection immediately behind the branchial groove (Pl. xl, fig. 1a, F).

Suborbital lobe armed with five or six spines. A short, stout spine and several smaller spines on subhepatic region, very close to posterior angle of orbit.

First antennae (Pl. xl, fig. 1b) with two flagella; peduncle stout, three-jointed, furnished with a few spines; inner lash short, composed of three rather robust articles, and outer flagellum four-jointed (the three basal articles stout) and with a brush of long hairs. Peduncle of second antennae (Pl. xl, fig. 1c) four-jointed, armed with some short spines and a few setae; second article with inner apical angle a little produced, and outer apical part prominently forwardly produced and lobular; flagellum slender, composed of eight articles.

Eyes large. Margins of ischium and merus of outer maxillipeds with short spines. Chelipeds and legs stout, armed with short spines, simple setae, and sparsely plumose setae.

Pleon bent under thorax, narrow, seven-segmentate, surface furnished with short spines and setae (Pl. xl, fig. 1d); lateral margins of telson sinuate and posterior margin incised; tumid posterolateral margins of telson with short spines; second to fifth segments with a spine at each posterolateral angle. Pleopods of second to fifth segments long, each with protopod stout and nearly half as long as the exopod, which is flattened and bears fourteen plumose marginal hairs

on the apical half; endopod small, unjointed, scarcely more than one-third as long as exopod, and with four tiny hooks near apex (Pl. xl, fig. 1f). Uropods represented by a tiny subcordate rudiment on each side (Pl. xl, fig. 1e. U).

Length of carapace, 1.86 mm.; width of carapace, 1.7 mm.

Growth Changes. Plate xl, B, figs. 2 and 3.

In a specimen 5.6 mm. in width (Pl. xl, fig. 2) the carapace is a little wider than long and its margins still bear spines, which are, however, very tiny. The supraorbital tooth (*B*) is relatively smaller than in the brood young and the small projection of the supraorbital border has disappeared. The posterior angles of the orbit are prominent (*C*), there is a little notch below the angle, and the inner angle of the suborbital border is spiniform. The two projections of the anterolateral margins each end anteriorly in a tubercle (*D* and *E*). The regions of the carapace are not defined but the branchial groove is distinct. A small subhepatic tooth (*S*) is developed.

As in *Cryptodromia octodentata*, the carapace becomes relatively wider behind the level of the orbits, and relatively narrower from this level forwards, at each moult; thus the distance between the hinder angle of the orbit (*C*) and the apex of the first tubercle of the anterolateral margins (*D*) gradually increases. Montgomery suggests that either the supraorbital tooth of the young or, alternatively, the tiny projection just posterior to it, becomes the posterior angle of the orbit in the adult; it is not probable that the orbit thus changes its position, nor is such conclusion strengthened by a comparison with the stages of *Cryptodromia*. The subhepatic tooth is not apparent in the brood young, but evidently appears at an early stage. Other mature characters develop as in the preceding species. An adult female (Pl. xl, fig. 3a) has the carapace distinctly wider than long; the supraorbital tooth is much reduced and no more prominent than the outer angle of the orbit. The inner flagellum of the first antennae consists of nine articles, and the outer of twenty-three articles, while the lash of the second antennae is twenty-jointed. As in *Cryptodromia octodentata*, the pleopods change utterly (Pl. xl, fig. 1f and 3b).

PLATYDROMIA THOMSONI Fulton and Grant.

A female of this small species, dredged by Sir Joseph Verco in Investigator Strait, South Australia, is 11 mm. in width and bears a score of eggs each more than 1 mm. in diameter. The ova are thus considerably larger than those of some crabs which are known to hatch as Zoeae; for instance, the numerous eggs of a large female of *Carcinides maenas* are only 0.29 mm. to 0.3 mm. in diameter. It is therefore likely that the young of *Platydromia* do not emerge from the eggs as Zoeae, but hatch at a later stage of development.

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EXPLANATION OF PLATES XXXIX-XL.

Plate xxxix.

Cryptodromia octodentata.—Female with young beneath the pleon; the sponge cloak of the mother is shown above (nat. size).

Plate xl.

A. Ovigerous female of *Cryptodromia octodentata* sheltering beneath the valve of a *Pecten* ($\frac{3}{4}$ nat. size).

B. *Paradromia lateralis*.

Fig. 1. Brood young; 1a dorsal view ($\times 17$ diams.); 1b and 1c, first and second antennae ($\times 57$ diams.); 1d, pleon ($\times 22$ diams.); 1e, lateral view of sixth and seventh segments of pleon ($\times 57$ diams.); 1f, pleopod of second segment ($\times 57$ diams.).

Fig. 2. Carapace of young example 5.6 mm. in width ($\times 6\frac{1}{2}$ diams.).

Fig. 3. Adult female; 3a, carapace ($\times 3\frac{1}{4}$ diams.); 3b, pleopod of fifth segment ($\times 7$ diams.).
